# Assimilation of Satellite Precipitation and Soil Moisture Data into the WRF-Noah Model

Rafael L. Bras[1], Liao-Fan Lin[1], Ardeshir M. Ebtehaj[2], Alexandro N. Flores[3], and Satish Bastola[1]

[1]School of Civil and Environmental Engineering, Georgia Institute of Technology
[2]Department of Civil, Environmental, and Geo-Engineering, University of Minnesota
[3]Geosciences Department, Boise State University

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# Outline

- Research Background and Motivations
- Joint Data Assimilation System and Experiment Setup
- Evaluation of Precipitation Analyses and Forecasts
- Evaluation of Soil Moisture
- Summary and Future Work

# Research Background and Motivations

- Atmospheric and land surface data assimilation have been developed separately for a long time

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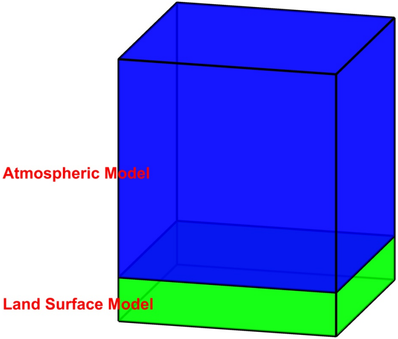


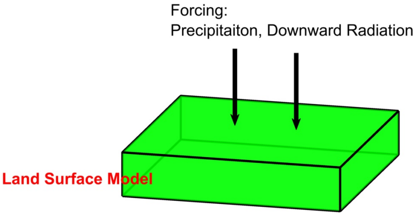

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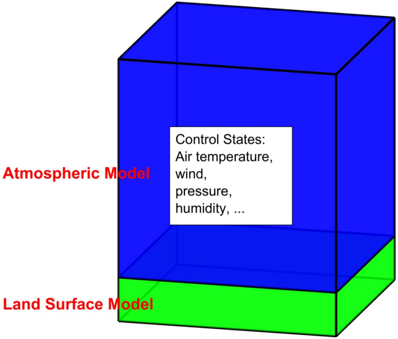


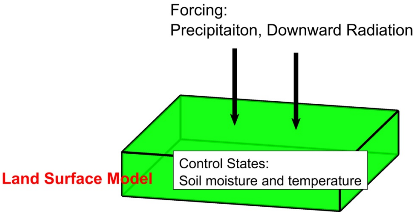


- Atmospheric Data Assimilation System:
  - Using mostly variational data assimilation
  - Fixing land surface states during the analysis procedure
- Land Surface Data Assimilation System:
  - Using mostly ensemble-based filtering
  - Updating only land surface states in the analysis procedure

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  - Precipitation: TRMM, GPM
  - Soil Moisture: SMOS, AMSR-E, SMAP

# Joint Data Assimilation System

- The coupled WRF-Noah model
- Similar data assimilation approaches for both atmospheric and soil moisture states:
  - Variational data assimilation scheme
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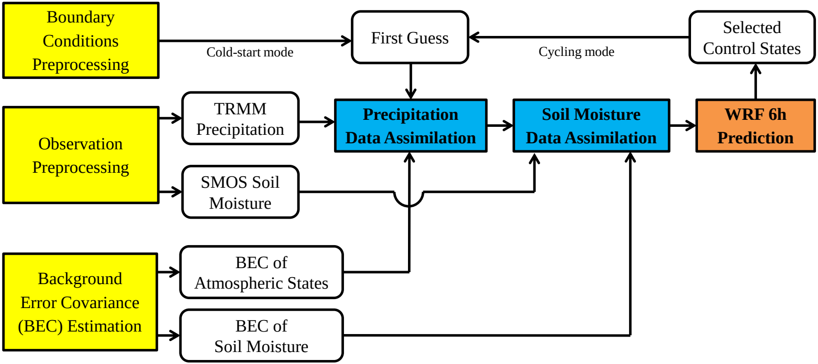

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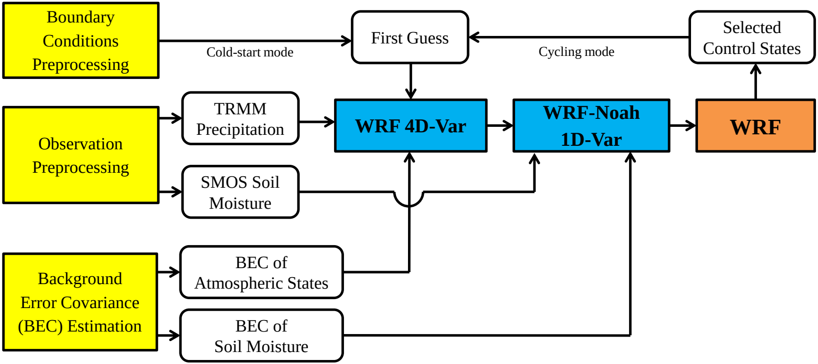
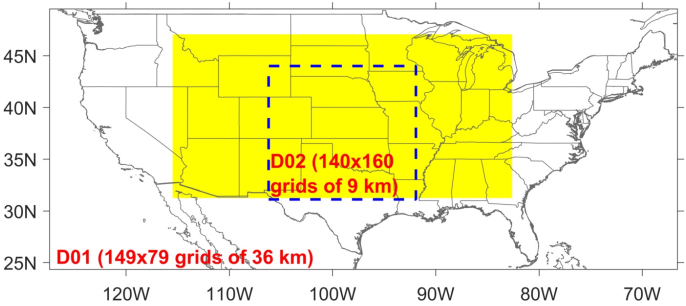
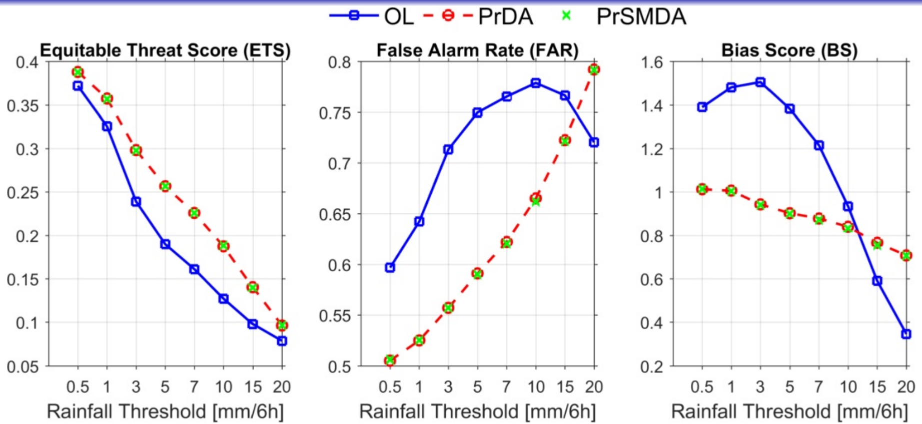


# Experiment Setup




- Experiment duration: July 1-29, 2013
- Experiments:
  - **OL**: no data assimilation
  - **PrDA**: assimilation of six-hour TMPA 3B42 precipitation data
  - **PrSMDA**: assimilation of six-hour TMPA 3B42 precipitation and orbital SMOS soil moisture data

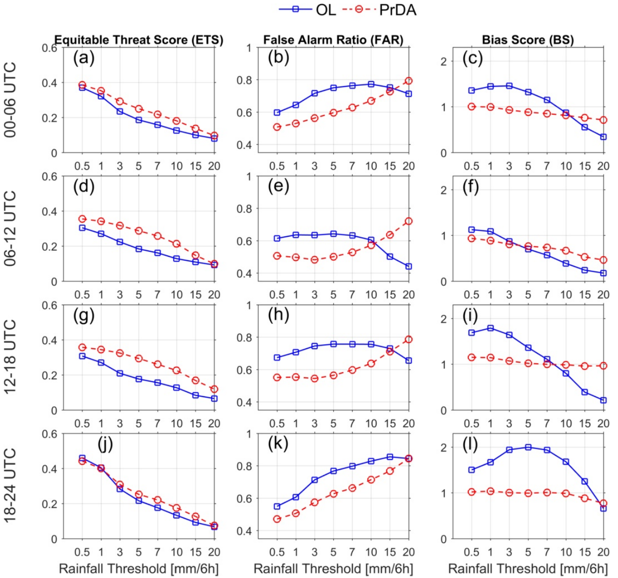
# Overall Score of the Precipitation Analyses



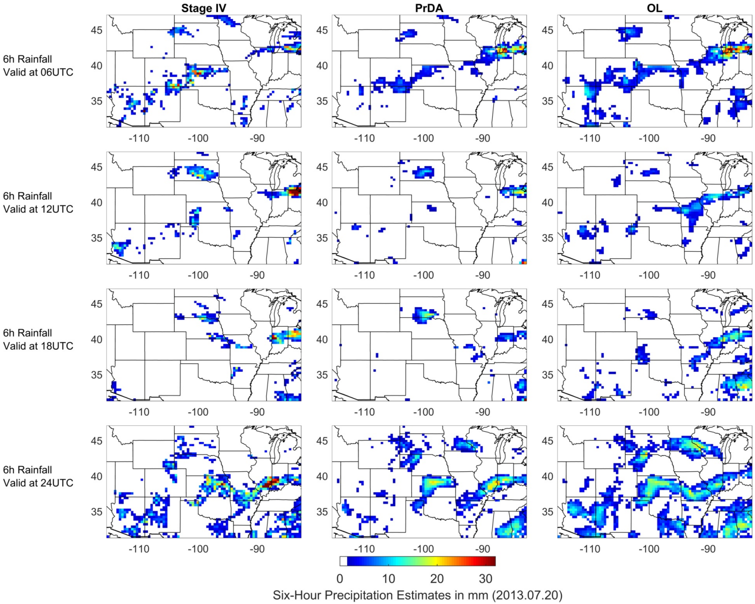

$$ETS = \frac{a - a_r}{a + b + c - a_r} \qquad FAR = \frac{b}{a + b} \qquad BS = \frac{a + b}{a + c}$$

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} = \begin{bmatrix} hits & falsealarms \\ misses & noforecasts \end{bmatrix} \qquad a_r = \frac{(a + b)(a + c)}{n}$$

# Score of the Precipitation Analyses (Different Times)



# Samples of Six-Hour Precipitation



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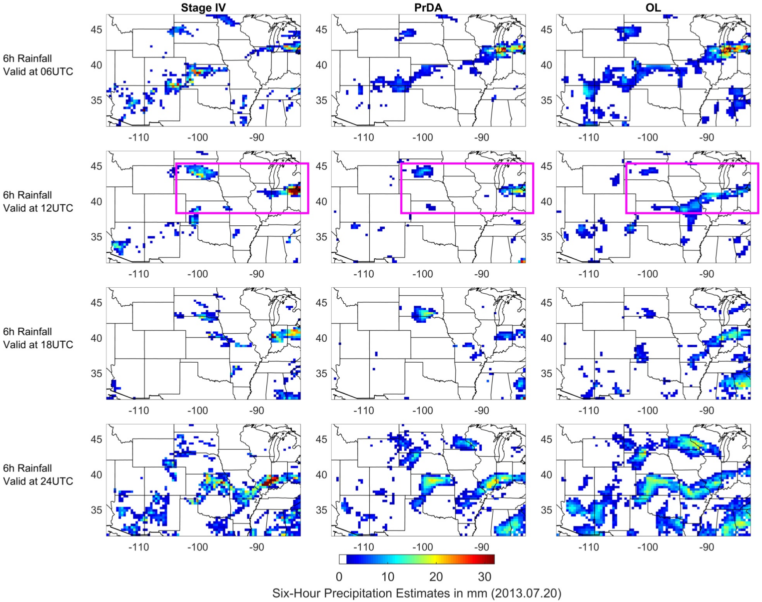

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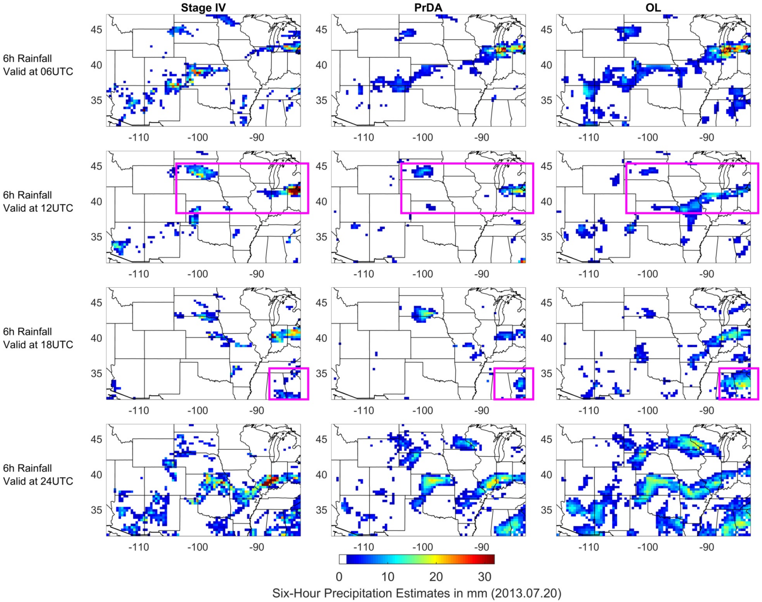

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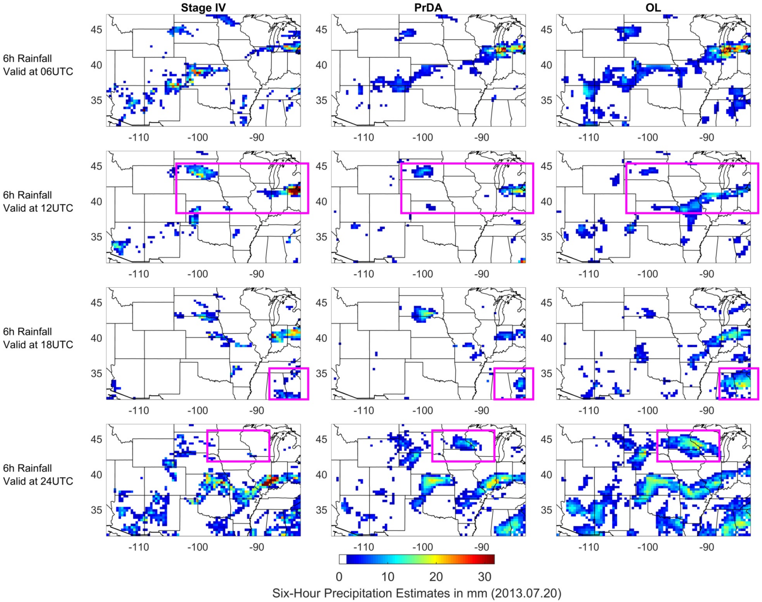
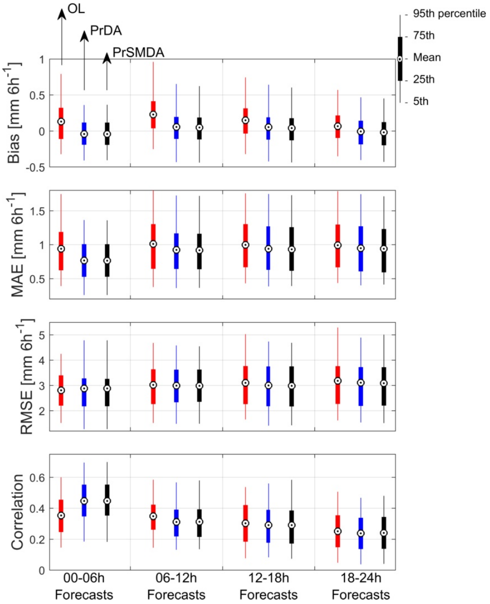
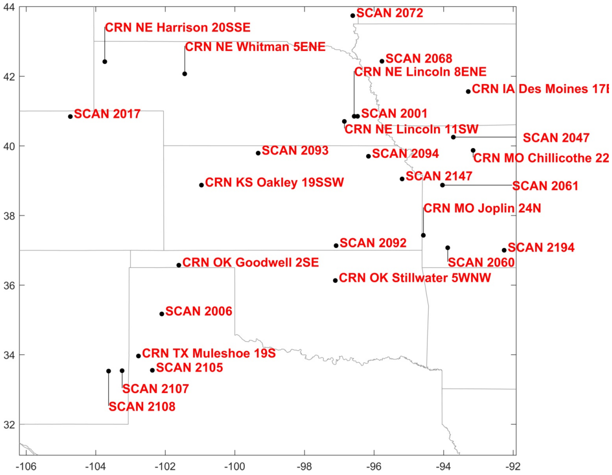


# Statistics of Precipitation Forecasts

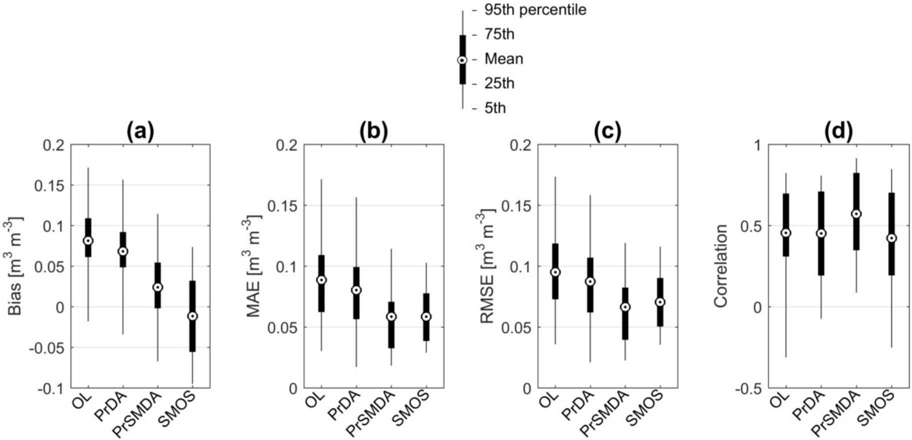


# SCAN and CRN Station Map



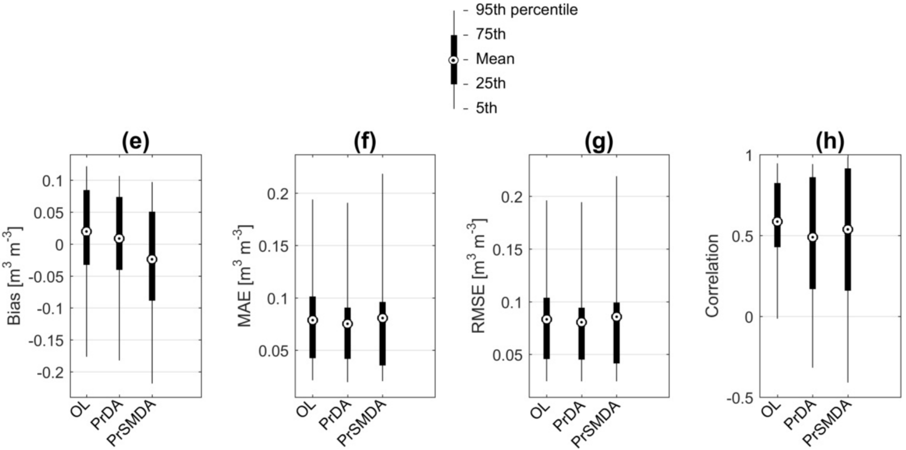

- SCAN: Soil Climate Analysis Network
- CRN: Climate Reference Network

# Statistics of Hourly Top 10-cm Soil Moisture Comparison



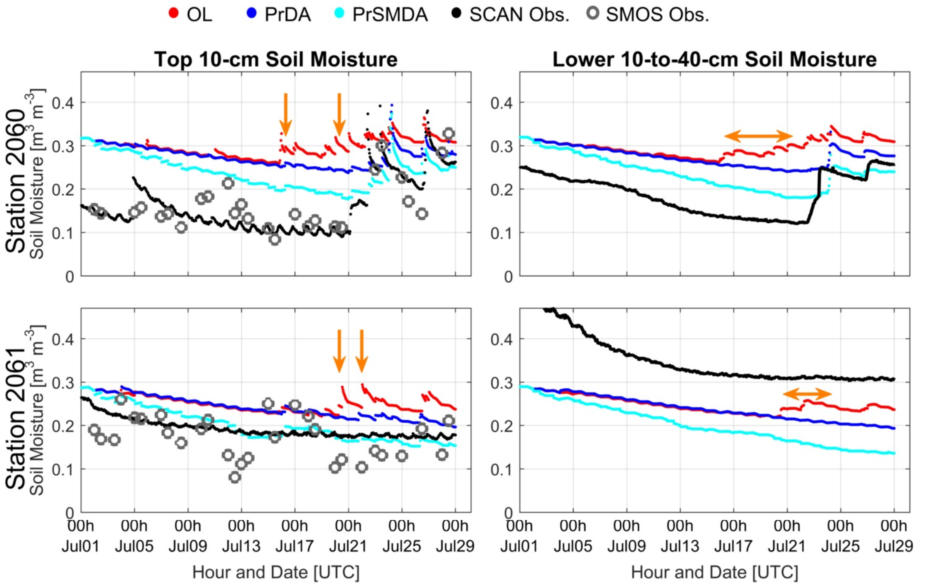

| Experiment\Improvement in | Bias | MAE | RMSE | Corr |
|---|---|---|---|---|
| PrDA | 16% | 9% | 8% | -1% |
| PrSMDA | 71% | 34% | 30% | 21% |

# Statistics of Hourly 10-to-40-cm Soil Moisture Comparison




| Experiment\Improvement in | Bias | MAE | RMSE | Corr |
|---|---|---|---|---|
| PrDA | 56% | 5% | 3% | -23% |
| PrSMDA | -21% | -2% | -6% | -12% |

# Selected Time Series



# Summary and Future Directions

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- Assimilation of TMPA 3B42 precipitation improves precipitation analyses significantly but its benefit drops quickly beyond the assimilation window.
- Assimilation of SMOS soil moisture has only marginal effect on precipitation analyses/forecasts.
- Both precipitation and soil moisture data assimilation can reduce surface soil moisture simulations, while has small to negative impact on lower layer soil moisture simulations.

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## Future Directions

- Bias characterization of satellite and model soil moisture data
- Assimilation of IMERG precipitation and SMAP soil moisture
- Assimilation of radiance observations from GPM constellation

# Thank you!


## Acknowledgments

- Fundings from NASA PMM and the K. Harrison Brown Family Chair
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